Joint position sense in the recurrently sprained ankle

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Functional instability of the ankle joint following an acute sprain has been well documented. The present study measured joint position sense of the ankle in subjects who had sustained recurrent ankle sprains but no sprain for at least three months prior to testing, and compared them with uninjured subjects. The testing device, a pedal goniometer, attempted to replicate the most common position of ankle injury (plantarflexion/inversion). Joint position sense was assessed using active and passive methods for reproducing predetermined positions in ankle inversion in plantarflexion. In both groups, passive judgment of joint position was more accurate than active judgment. Significant differences were recorded with the recurrently sprained ankle demonstrating greater errors in joint position sense for all passive testing positions.

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Ankle sprains are among the most commonly sustained injuries during sporting activity. The majority of sprains occur when the ankle is suddenly plantarflexed and inverted, causing injury to the lateral ligament complex. Freeman (1965) reported that 10 to 30 per cent of individuals who have sustained acute lateral ligament sprains may continue to suffer from chronic symptoms.

Ankle instability can be defined as either mechanical instability or functional instability. Mechanical instability of the ankle refers to objective measurements, either clinical or radiographical, of "motion beyond the physiologic range of motion" (Peters et al 1991, p. 183). This may be confirmed objectively by clinical tests such as the anterior drawer test and/or the talar tilt test, and by radiographical stress tests. Functional instability of the ankle, by comparison, is a term that was introduced by Freeman (1965) to describe the patient's subjective complaint of a tendency for their ankle joint to "give way".

The mechanical signs and the functional symptoms of ankle instability may coexist, but they may not be correlated in individual subjects. Freeman (1965a) reported that mechanical instability was not significantly associated with later functional instability, although he conceded that it may play a role in its aetiology. Nor could functional instability be attributed to subtalar joint instability, calf muscle weakness or tibiofibular diastasis. Tropp et al (1985), using stabilometry measures of soccer players, reported that more than 50 per cent of functionally unstable ankles in their study were, nevertheless, mechanically stable.

There have been many methods devised to assess ankle proprioception. The pedal goniometer is a device that was designed to enhance the accuracy of assessment of ankle joint position sense in the clinical setting (Gordon 1988). It was developed on the premise that an individual's perception of changes in joint angle, away from the neutral position, corresponds with the quantification of joint position sense. Individuals with uninjured ankles were found to be capable of perceiving less than 1 degree of movement in the sagittal plane (Gordon 1988). Chan et al (1990) described a pedal goniometer which quantified the range of ankle inversion in 42 degrees of plantarflexion. A high level of intra-tester and inter-tester reliability was reported for this device. The axis of rotation of this goniometer, 42 degrees from the transverse plane, corresponds with the physiological axis of rotation of the subtalar joint (Root et al 1977). In addition, inversion whilst in the plantarflexed position attempts to replicate the direction in which most ankle sprains occur.

Clinical assessments of proprioception, including joint position sense, are frequently used by physiotherapists to determine the severity of functional deficit after an ankle sprain, and to determine the effectiveness of subsequent treatment. It is also common practice for physiotherapists to include exercises designed to retrain proprioception in the rehabilitation of ankle sprains. The purpose of this study was to compare joint position sense in uninjured and recurrently sprained ankles in the most common position of injury (plantarflexion/inversion) using the pedal goniometer. Comparison of two methods of testing (active and passive) and the influence of different positions within inversion range of motion for repeated trials was studied.

Method

This study included a control group in which subjects reported no history of ankle trauma (uninjured) and an injured group consisting of individuals with a history of recurrent ankle sprains (recurrently sprained). The uninjured group consisted of 67 subjects (36 females and 31 males) between the ages of 18 and 25 years (mean = 20.6 years). The recurrently sprained group consisted of 25 subjects (17 females and 8 males) between the ages of 19 and 25 years (mean = 21.6 years). Subjects in this group had sustained recurrent sprains of the ankle being tested. A recurrently sprained ankle was defined as having sustained two or more sprains of the lateral ligament complex, with or without subjective complaints of giving way, but with no acute episode within the three months prior to testing. No palpable effusion nor pain was allowed to be present in the ankle at the time of or during testing. A questionnaire and interview were completed for each subject to establish their past history of injury and thereby their eligibility for inclusion in the study. The subject's sprain history included recall of signs and symptoms, degree of functional deficit at the time of injury and the treatment they had received.

Subjects were excluded from either group if any of the following were applicable:

a) history of orthopaedic or arthritic condition, other than sprain, affecting the testing ankle;
b) existence of any major medical illness or neurological problem;
c) inability to achieve 42 degrees of plantarflexion movement;
d) applicants were qualified physiotherapists or undergraduate physiotherapy students in second year or above.

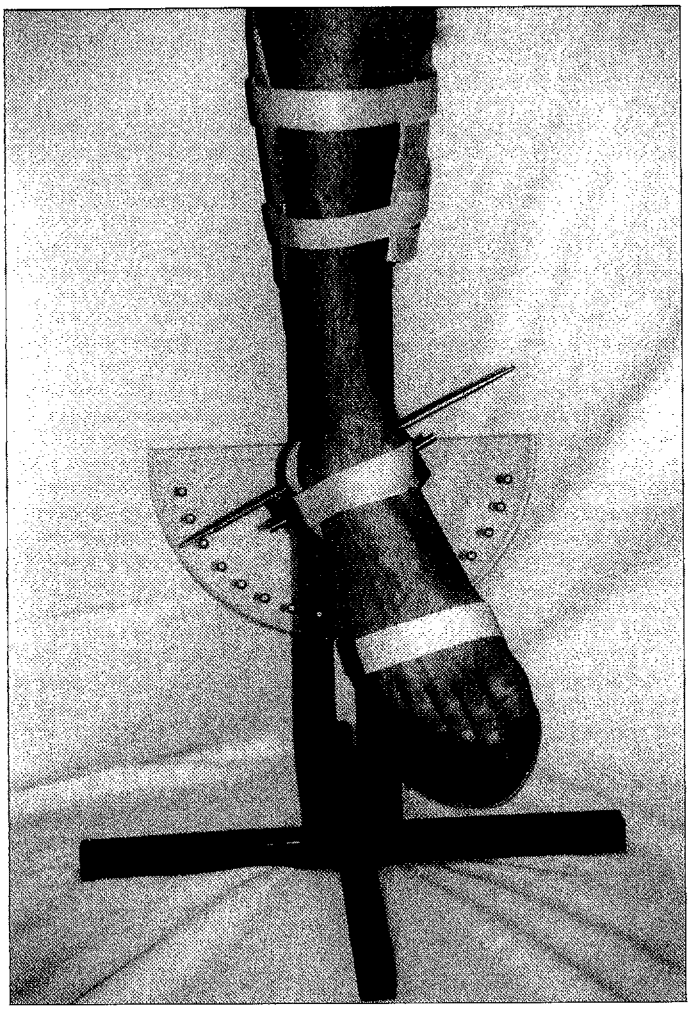

Figure 1. Measurement of joint position sense in inversion in 42 degrees of plantarflexion using the pedal goniometer.

Informed consent was gained and the subjects were instructed that they could withdraw at any stage of the testing without penalty or prejudice. Ethical approval for the study was granted by the Human Research Ethics Committee of Curtin University.

Instrumentation

Joint position sense testing was performed using the pedal goniometer (Figure 1). The subject's foot was set on the pedal in 42 degrees of plantarflexion, allowing ankle inversion to occur through the frontal plane along a horizontal axis. The subject's calcaneum was stabilised by an Orthoplast cuff. The subject's leg and foot were fixed to the pedal goniometer without hindering movement at the subtalar joint, as described by Chan et al (1990).

Procedure

Each subject's ability to reproduce predetermined joint positions was tested. Each testing session followed a standardised procedure and standardised verbal instructions. Subjects were blindfolded to ensure elimination of visual cues. Prior to testing, subjects in both groups performed a set of supervised warm-up exercises consisting of passive stretches and active ankle movements.

Joint position sense was assessed by taking each subject's ankle into three

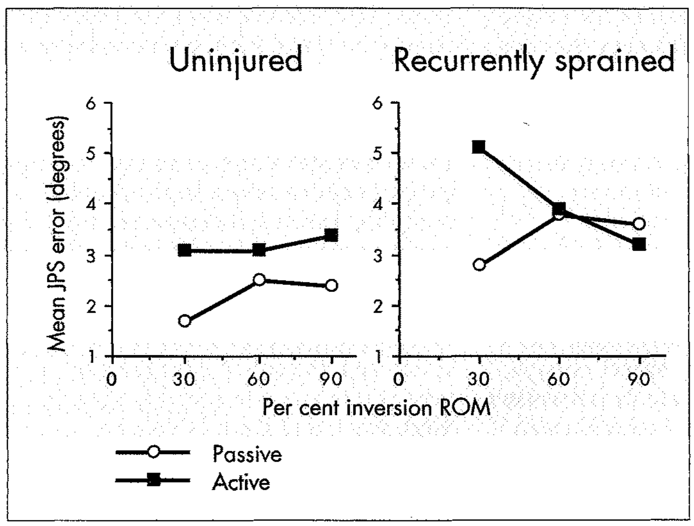

Figure 2. Mean joint position sense error for uninjured and recurrently sprained subjects comparing passive and active testing methods. (JPS: joint position sense; ROM: range of motion).

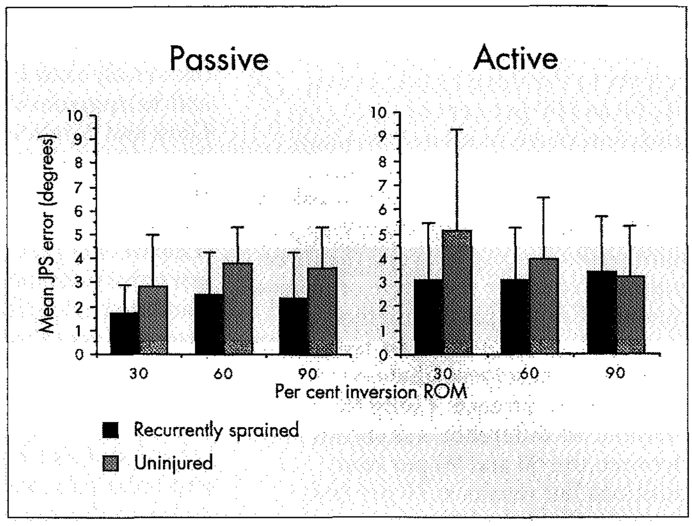

Figure 3. Mean joint position sense error for passive and active testing methods comparing uninjured and recurrently sprained subjects. Error bars represent SD. (JPS: joint position sense; ROM: range of motion).

different positions of inversion. These were 30, 60 and 90 per cent increments of the subject's total range of active ankle inversion, in 42 degrees of plantarflexion, as measured by the pedal goniometer. Percentages of range of movement were used to ensure that positioning of the subject's ankle was relative to their individual range of motion. To assess joint position sense, the subject's ankle was moved manually at a rate of approximately 5 degrees per second (Gross 1987) from the starting position (neutral inversion/eversion) to the first testing position. The subject was given three seconds to register the position before the ankle was returned to the starting position. In the passive test the ankle was moved passively into inversion at the same rate of movement, and the subject was asked to say "stop" when they perceived that the test position had been reached. If the subject felt that they had overshot the position, their ankle was passively returned to correct this. In the active test the subject performed an active inversion movement aiming to stop their movement at the test position. The order of testing (three different positions and two different methods) was randomised.

The difference between the actual and perceived position was recorded as the absolute error, to the nearest 0.5 degrees. Three trials were performed in each position for both active and passive testing.

Reliability

Intra-tester reliability was measured for the uninjured and the recurrently sprained groups by randomly selecting 10 subjects from each group and repeating the standardised protocol on two separate occasions. The same examiner was tested for all subjects in each group. Intraclass correlation coefficients were calculated.

Data analysis

Each group's data were analysed using a three factor ANOVA for (a) testing methods (active and passive), (b) positions (30, 60 and 90 per cent of total active inversion range of motion in plantarflexion) and (c) trials (1, 2 and 3) using the SuperAnova statistical program. Due to uneven group numbers, uninjured and recurrently sprained group data were compared using unpaired, two tailed t-tests using the Statview statistical program.

For all tests of statistical significance, a probability of $p < 0.05$ was accepted as representing meaningful differences.

Results

The reliability of the testing protocol was measured for all six testing procedures (two methods and three positions) in the uninjured subjects. Intraclass correlation coefficients recorded moderate to high reliability in all testing procedures (passive 30 = 0.63, passive 60 = 0.98, passive 90 = 0.73, active 30 = 0.60, active 60 = 0.75 and active 90 = 0.65).

The total active inversion range of motion in 42 degrees of plantarflexion ranged from 25 to 58 degrees in the uninjured subjects with a mean (SD) of 40.3 (6.7) degrees, and 31 to 49 degrees in the recurrently sprained subjects with a mean (SD) of 39.7 (4.8) degrees.

In analysis of the uninjured group data a significant difference was noted between Trials 1 and 2 ($p < 0.001$) and Trials 1 and 3 ($p = 0.001$). A small learning effect was considered to have occurred. However no difference was recorded between Trials 2 and 3 ($p = 0.313$). No differences were noted between trials in the recurrently sprained group data. As a consensus for all testing an average of Trials 2 and 3 was used in data analysis.

The resultant data were analysed with respect to the three testing positions of 30, 60 and 90 per cent of total inversion range of motion in 42 degrees of plantarflexion (Figure 2). For the subjects with uninjured ankles, there was no significant difference in joint position sense between the three positions in either the active or passive method. For the passive method of testing, all positions for the recurrently sprained subjects recorded no significant difference. Using the active method, no difference was shown between the 60 and 90 per cent positions but results at 30 per cent were significantly different from the 90 per cent position data ($F_{(2,24)} = 5.03$, $p = 0.03$).

In the uninjured group, active judgments of joint position were shown to be less accurate than the passive judgments ($F_{(1,66)} = 29.01$, $p < 0.001$). Similarly, in the recurrently sprained group, the measures for the active 30 per cent position demonstrated greater error in judgment of joint position ($F_{(1,24)} = 7.96$, $p = 0.01$). However, there was no such difference between the two methods of assessment in the recurrently sprained group for the 60 and 90 per cent positions of testing ($F_{(1,24)} = 0.18$, $p = 0.829$).

Using the passive method to assess joint position sense for the uninjured and recurrently sprained groups a significant difference between these two groups was recorded for the 30 per cent ($t_{(90)} = 3.07$, $p = 0.003$), 60 per cent ($t_{(90)} = 3.20$, $p = 0.002$) and 90 per cent ($t_{(90)} = 2.65$, $p = 0.009$) testing positions. Using the active method, a significant difference was recorded for the 30 per cent position ($t_{(90)} = 2.94$, $p = 0.004$). There was no difference between the uninjured and the recurrently sprained groups for the 60 per cent ($t_{(90)} = 1.64$, $p = 0.105$) and 90 per cent ($t_{(90)} = -0.26$, $p = 0.799$) positions (Figure 3).

Discussion

Numerous methods and instruments have been used to quantify joint position sense for the ankle. Assessment of the ability of the subject to stand on one leg with eyes closed is commonly used in the clinical setting and in research (Forkin et al 1996, Garn and Newton 1988). Quantification of postural sway in standing, using the stabilometry technique, has been reported (Leanderson et al 1996). Similarly, assessment of postural control whilst standing on a wobbleboard has been examined (De Carlo and Talbot 1986, Ryan 1994). However, these techniques do not isolate variations in performance to the ankle region and other factors such as visual and vestibular cues, neuromuscular control and the influence of other joints may be involved. However, these tests do have the advantage of testing in the weight bearing position. Other studies have used instruments such as passive movement platforms, goniometers or isokinetic dynamometers (Forkin et al 1996, Garn and Newton 1988, Glencross and Thornton 1981, Gross 1987). These instruments quantify the reproduction of joint position (either by active or passive motion) or the detection of changes in joint position. All of these methods are, therefore, able to objectively isolate the measurement of joint position sense at the ankle, albeit in the non-weight-bearing position. Complementing this research, the present study measured ankle joint position sense by attempting to replicate the joint's most vulnerable position for injury, that is by placing the ankle into the plantarflexed and inverted position. In doing so, the use of the pedal goniometer to quantify joint position sense was demonstrated to be reliable in all testing procedures.

The range of active inversion motion, in the 42 degrees plantarflexed position, was comparable for the two groups assessed, and compares favourably with Chan et al (1990). In the uninjured group, the use of active judgments of joint position resulted in greater error when compared with the use of passive judgments. This finding supports Gross (1987) who posed the hypothesis that muscle receptors are most concerned with detecting joint movement whereas joint receptors are most concerned with detecting joint position. The literature, however, is at debate regarding the relative contribution of the muscle, tendon and joint mechanoreceptors to the proprioceptive reflex. In the current study the greatest difference in joint position sense error occurred in the recurrently sprained 30 per cent position. Despite having a passive result consistent with that of the uninjured, the active joint position sense error was considerably greater. Konradsen and Ravn (1990), in studying functional ankle instability, reported a prolonged peroneal reaction time when the ankle is suddenly inverted through 30 degrees of motion. The deficit in reflex stabilisation of the ankle may be most evident in the early range of inversion motion due to the decreased joint position sense via the "active motion" mechanoreceptors.

Using the active testing method (reproducing joint position using active movement), the two groups recorded similar errors in detecting joint position in the majority of positions tested. However, with the passive method (reproducing joint position using passive movement), a statistical difference was demonstrated. Using passive judgments as indicators of joint position, subjects with recurrently sprained ankles were considerably less accurate than uninjured subjects. Garn and Newton (1988) and Forkin et al (1996) also reported a significant deficit in passive joint position sense following recurrent sprains of the ankle. By comparison, Gross (1987) reported no difference but he does question his own findings relative to the small sample size studied. Garn and Newton (1988) demonstrated decreased ability to detect motion in 67 per cent of subjects with recurrently sprained ankles using a passive movement test, and in 53 per cent of the same subjects using a single limb standing balance test. Forkin et al (1996), using the standing balance test, also reported impaired proprioception in 63 per cent of subjects with recurrently sprained ankles. Similarly, after a single ankle sprain, subjects demonstrated an increase in postural sway in single leg standing as compared with their pre-injury performance (Leanderson et al 1996). Ryan (1994) made the task more difficult by standing the subjects on a wobbleboard and reported that subjects with unilateral functional instability had significantly less dynamic control when weight-bearing through their affected limb.

The reduction in joint position sense following ankle sprain is not only present in the acute inflammatory phase of injury. Garn and Newton (1988) demonstrated proprioceptive deficits in individuals who have sustained multiple ankle sprains, six months after the most recent injury. The present study agrees with this finding, demonstrating that joint position sense deficits exist after three months following an acute episode in the recurrently sprained ankle. However, a limitation of the current study was the retrospective analysis of the ankle sprains.

To reduce the demonstrated deficit in joint position sense following ankle sprain, and its potential for causing recurrence of injury, exercises which have been suggested to retrain joint position sense may be beneficial. For example, Leanderson et al (1996) reassessed postural stability, using stabilometry, in six subjects following a period of rehabilitation after a single ankle sprain. All six demonstrated improvements, with four of the six regaining their pre-injury level.

Conclusion

Using the pedal goniometer, this study has demonstrated a measurable deficit in passive joint position sense in individuals with recurrently sprained ankles. This method replicated the common direction of ankle sprain by quantifying joint position sense of inversion in the plantarflexed position. The authors propose that the pedal goniometer may be a useful assessment tool in future research studies which investigate the success of rehabilitation programs aimed at improving ankle joint position sense. The pedal goniometer may also be of value in clinical practice where definitive measures of joint position sense, and/or an accurate reassessment of the individual's progress with rehabilitation, are desired.

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